# NUMERICAL COUPLING OF RIVER DISCHARGE TO SHELF/SLOPE SEDIMENTATION MODELS



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## LONG-TERM GOALS:

An important objective of the Office of Naval Research is to develop a numerical predictor of the acoustic signature of continental margins based on a region's geologic and climatic history. To meet this objective our group's long-term goal is to develop and improve upon existing models useful for the simulation of sediment delivery, reworking and accumulation on continental margins over time scales of tens to thousands of years. The model predictions increase our understanding of the complex and often non-linear interactions of the processes affecting the evolution of a margin's structure and sediment character.

## SCIENTIFIC OBJECTIVES:

- Develop a nested set of models to study the interactions of sedimentation processes on the shelf, including the effects of river supply, plume transport and initial deposition of sediments.
- Analyze the effects on the resulting sediment sequences of a range in river discharge characteristics from a storm flood dominated system to a more continuous discharge system.
- Analyze the effects on the resulting sediment sequences of the temporal coherence of river discharge events and ocean storms.
- Establish the importance and determine the effects of climate change on sediment supply and distribution on a continental margin.

## BACKGROUND:

The supply, deposition, reworking and subsequent burial of sediment on continental margins is controlled by a dynamic set of processes. The initial deposition is influenced by the river dynamics, coastal currents, surface and internal waves and tidal forcing. The final preservation of the sequence depends on the relative magnitudes and the complex spatial and temporal interactions of these processes. Most of the individual processes have been studied in detail. However, few attempts have been made to create a unified model of the processes which build spatial sediment sequences through time. The sequence modeling to date has focused on either the boundary layer dynamics at one location on the margin using inference to connect individual sites, or have model cross shore profiles using geometric based rules over long time steps (thousands of years). Our efforts are aimed at bridging the gap between these two endpoints using process based spatial models to study the processes, their interactions and the resulting deposits over tens to thousands of years.

## APPROACH:

To meet the stated goals, a "source to deposit" modeling approach has been implemented which includes the major processes linking the initial riverine sediment load to the final depositional sequence. The integrated set of models are used to test a number of hypothesis concerning the importance of each of process and more importantly the process interactions which control sedimentation on a margin. The ultimate sediment "source" is the river for which we use a hydrologic water-balance model which simulates the daily input of water and sediment to the margin from rainfall, snowmelt, glacial and groundwater sources. The hydrological model feeds into a river plume model which predicts the dispersion and sorting of sediment onto the margin through a surficial momentum-driven plume. An additional suite of models (not discussed in detail here) rework the sediment through time due to process such as: boundary layer dynamics, turbidity currents, debris flows, compaction and sea-level changes. The entire suite of models build realistic sedimentary sequences, which are used to produce synthetic seismograms and cores which can be compared to measured values. The tasks for this portion of the study are concerned with the input and initial dispersion of sediment onto the margin.

The first step in this project is to modify the river basin and plume models to simulate the dynamics for a generalized continental shelf setting. The second step is to validate the models with modern conditions for the Eel River Basin. Climate proxy data are then used to reconstruct the Holocene climate history of the basin. The reconstructed climate time series are used as model input to simulate the Holocene sediment deposition, reworking and final burial of sequences. The sediment sequence reconstructions will be compared with data collected by the STRATAFORM project to verify the entire suite of models. The strength and uniqueness of this modeling approach is that sensitivity tests will be run on the verified models to study the importance of interactions between each of the forcing functions. Other modeling approaches and field based studies have a difficult time assessing the interactions of these processes over the time scales of thousands of years.

## ACCOMPLISHMENTS AND RESULTS:

The river basin simulator (HYDROTREND) has been modified to simulate the rain flood dominated river processes of the Eel River. The model accurately reproduces the modern flood frequency discharge curve and the sediment rating curve of the Eel River indicating that it will realistically supply water and sediment to the Eel Shelf. The model simulations using 18ka climate proxies have been used to study the changes in discharge and sediment load caused by the cooler and wetter climate of the last glacial maximum. Work is in progress to generalize this model to large basins and to simulate arctic rivers. How sediment load varies through time with changing climate and basin characteristics is also being studied.

The river plume model (PLUME) has been modified to integrate the effects of alongshore currents and address the changes due to the Coriolis force. Significant advances in the model have been implemented due to the data collected by other STRATAFORM members during the 1997 season. The model has recently been reformulated for inclusion into the 3-D model, with an increase in speed and capabilities.

Simulations of the 1995 and 1997 flooding events of the Eel River have been made. The simulations show that most (>90%) of the sediment leaves the surface plume within a short distance (<10km) of the river mouth and stays close to the shoreline. The observed silt and clay deposits occurred at distances greater than this (and to the Northwest) from the river mouth. This indicates the sediment leaving the surface plume is further transported by the intermediate depth currents and the bottom boundary layer prior to initial sedimentation.

## SCIENTIFIC IMPACT AND TRANSITIONS ACCOMPLISHED:

A series of robust numerical models are being created to simulate the formation of stratigraphic sequences. The models are providing a key link between process based studies on short time scales (seconds to years) and geologic time scale basin sediment models (time steps of thousands of years). The conversions to 2-D fluid dynamics and 3-D deposits is underway. Key insights are being gained on how sediment input from rivers varies through time and on where sediment initially leaves the river plume.

Using these models we have been able to look at sediment delivery conditions during the last glacial maximum and investigate plausible sedimentation patterns for that time period. We are also starting to understand the importance of the coherence of ocean storms and river discharge events. When the storms and floods happen concurrently, the river supplied sediment spreads out in a band very near the coast. The storms then rework the sediment and disperse it across the shelf. This situation is analogous to a line source of sediment for the Eel margin. When the floods are asynchronous with the ocean storms, then the river supplied sediment can disperse in a variety of directions from the river mouth. This situation acts more like a point source of sediment. The Columbia River is an example of this type of sediment delivery.

## 1996/1997 PUBLICATIONS SUPPORTED BY ONR:


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